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MULTISCALE STOCHASTIC STRESS ANALYSIS FOR RANDOMNESS OF FIBER ARRANGEMENT IN FIBER REINFORCED COMPOSITE MATERIAL

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In this report, a multiscale stochastic stress analysis of a unidirectional fiber reinforced composite material considering a random variation of fiber arrangement is discussed. A composite material has a complex microstructure, and its microscopic property has a complex influence on both macroscopic equivalent properties and microscopic stress field. In addition, to assess reliability of a composite structure or perform the validation and verification of the computer simulation, a multiscale stochastic analysis becomes one of important topics in computational mechanics field.

For example, Kaminski[1], Xu[2] or Sakata et al.[3] reported a computational method for stochastic homogenization problem on elasticity. These reports mainly aim at investigation of influences of a microscopic randomness on a macroscopic equivalent property of composites, and propose an efficient method for the multiscale stochastic problems.

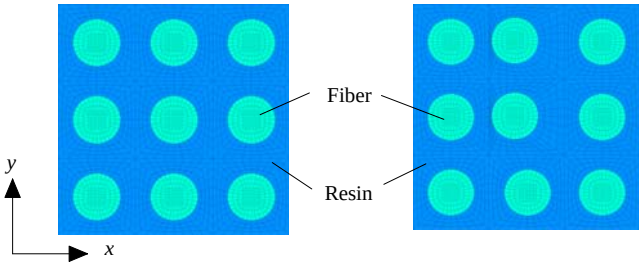
A multiscale stochastic stress analysis, especially for investigating influences of the microscopic randomness on both macroscopic and microscopic stress fields has been also reported[4][5]. From the related reports, it is recognized that the multiscale stochastic stress analysis should be also performed for reliability evaluation of composite structures.

In this report, influences of a random variation of fiber arrangement on the microscopic stress field are investigated. At first, the Monte-Carlo simulation is performed for the multiscale stochastic stress analysis. The multiscale stress analysis problem is solved by the homogenization theory, and the influences on both the macroscopic equivalent elastic property and the maximum stress are shown

Figure 1 shows the schematic view of the target problem. For this miscrostructure, the microscopic stress distribution is shown in Fig.2. Figure 2 shows the microscopic stress distribution of σ_x under x-direction loading. It can be recognized that a higher stress is observed according to a random variation of fiber arrangement.

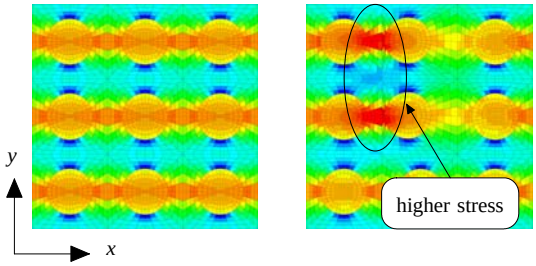
For this structure, the multiscale stochastic stress analysis is performed. The coefficient of variance (CV) of the equivalent elastic properties and the microscopic stresses for some cases of random variations of fiber arrangemen, are illustrated in Figs.3 and 4, respectively. The legend in the figures indicates the direction of random variation in fiber arrangement. From these results, it can be recognized the influence of the random variation of the fiber arrangement on the microscopic stress is larger than that on the equivalent elastic property, and it shows importance of the multiscale stochastic stress analysis.

In addition, the perturbation-based approach is applied to solve the problem. With comparison between the numerical results, applicability of the perturbation-based approach will be discussed in the presentation.



(a) regular arrangement (b) irregular arrangement

Fig.1 Schematic view of microstructure



(a) regular arrangement (b) irregular arrangement

Fig.2 Microscopic stress distribution

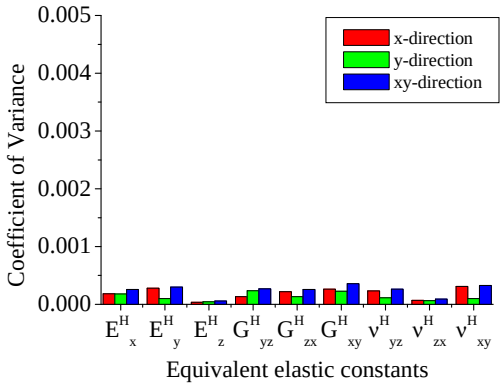


Fig.3 CV of the equivalent elastic constants

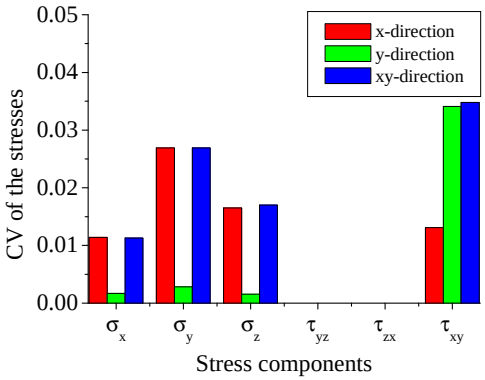


Fig.4 CV of the microscopic stress

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